Analysis of the Strength of the Market Movement Using the Information Content in the Trading Volume

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Abstract

In the context of the literature on behavioral finance, we aim to obtain an indicator able to capture information cascades or herding behavior at the very beginning: the distribution of market strength across returns. To do this, we first incorporate the information embedded in the trading volume to assess the strength of the market movement. Then, we show that its distribution, the distribution of market strength across returns, is a helpful instrument to identify the market opinion on the evolution of market prices and also, it is able to capture information cascades or herding behavior. Finally, we introduce the market strength weighted return as a measure to improve the information content of the data used for market analysis. The empirical analysis is applied to the Spanish Future on IBEX-35 during 2004.

Keywords: market behavior, trading volume, strength of the market movement, distribution of strength across returns, robust market returns.

JEL Codes: G12, G14, G15.

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1 Introduction

Over the last years, the evolution of the markets shows that the assumptions that the asset pricing models make on nonexistent transaction costs, market efficiency and rational behavior of the agents are systematically violated. The literature on behavioral finance focuses on the last factor: the breach of the assumption of agents’ rational behavior on the financial markets, and contributes to explain and predict the systematic implications of the cognitive processes of decision making present in financial markets (Olsen, 1996; Thaler, 1999). This stream of research began as a response to the increasing interest of practitioners on the impact that cognitive processes exert on decision criteria (Slovic, 1972; and Tversky and Kahneman, 1974), and argue that certain financial phenomena are better understood by introducing non-rational agents on the asset pricing models.

There are two main pillars of the behavioral finance literature (Shleifer and Summers, 1990): a) limits to arbitrage, whereby a substantial impact might exist if there is any interaction between rational and non-rational agents (Mullainathan and Thaler, 2000); and b) cognitive psychology, which catalogues the kind of deviations from the rational behavior assumed by the market efficiency hypothesis (Fromlet, 2001). The solutions proposed by this literature are useful for the individual investor since they widen the perspective on her environment and provide a deeper knowledge of the consequences implied by certain behavior patterns on the asset prices. From the authorities perspective, the advances in this research field facilitate the adoption of ex-ante measures that avoid abrupt endings associated to non-rational behavior such as, for instance, a stock market crash originated by a herd behavior and non supported by the real economic situation.

The main aim of this paper is to provide some tools to detect episodes of herding or information cascades right at the beginning. In this way, these instruments could be of help for investors and monetary authorities to react in time to extreme market reactions. The basic idea behind the model in this paper is that there exists a certain threshold upon which agents do not follow their own pricing rules but follow the market stream in order to avoid being trapped in their initial positions as on the information cascades or herding episodes. Therefore, this article aims to contribute to the psychological perspective by: first, developing a new indicator for the strength of the market movement that identifies the degree of market support to a certain trend. Second, we use this new indicator of movement strength to calculate the distribution of strength across returns, which offers a global perspective of the importance associated to each possible return at any point in time. Finally, we propose a new approach
to calculate the representative market return as the market strength weighted return, which improves the information content and the robustness of the measures for the evolution of market.

The remaining of this paper is organized as follows: Section 2 presents an overview of the literature while section 3 develops the model of agents’ behavior. Section 4 details the empirical analysis and, finally, section 5 summarizes the main concluding remarks.

2 Literature Review

Behavioral Finance aims to explain many reactions of financial markets that seem to be contrary to conventional theory and thus, can make an important contribution to avoidance of serious mistakes (Fromlet, 2001). The psychology approach included in the literature on Behavioral Finance (Barberis and Thaler, 2003) typifies the various deviations from rational behavior observed in human actions. Some of these deviations are imitation processes (Scharfstein and Stein, 1990; Bannerjee, 1992); disposition effect (Shefrin and Statman, 1985) heuristics dealing with information, varying availability of information, preference for certain news, differences in interpretation, the psychology of sending messages and anchoring (Fromlet, 2001); gender and overconfidence (Barber and Odean, 1998); control illusion (Shiller, 1999; Gervais and Odean, 2001); disposition effect (Odean, 1998); and following the herd (Eguiluz and Zimmermann, 2000).

Besides, the literature on Prospect theory initiated by Kahneman and Tversky (1979) analyses factors such as loss aversion (Kahneman and Tversky, 1992) and mental accounting (Shiller, 1999). These are some of the behavior patterns observed in financial markets that systematically violate the rational assumptions made by the neoclassical school.

This article contributes to the literature on Behavioral Finance by proposing a new indicator of Strength of the Market Movement based on a model for herding behavior. All the above mentioned issues, especially information cascades and herding are somehow reflected on financial variables such as returns, trading volumes or volatilities. We focus on the first two elements, returns and trading volumes, to build a new indicator that reflects agents’ opinion on the market evolution, and that can constitute a helpful tool to detect episodes of herding behavior on the very short run.

In panic situations, certain decisions that are rational at an individual level cause an irrational result at an aggregate level. For instance, the classical ex-
ample of a cinema fire shows how the individual rational decision of “leaving among the firsts” turns out to be chaotic and irrational when a relatively big group of people try to “leave among the firsts” at the same time. This type of chaotic situation also takes place in financial markets. As we will explain in detail, under certain circumstances the rational individual decision of selling a certain asset might trigger the massive sale of such asset at any price. This phenomenon is known as Irrational Exuberance (Greenspan, 1996; Shiller, 2000).

Herding behavior is an indication of the imitation processes that take place in the market and that can be observed in both upward and downward trends. In an upward trend, only quite a few assets increase their price. This is due to investors that think that these assets are underpriced (that is, that the asset is relatively cheap) and therefore they buy it at higher prices until the new equilibrium price. Besides, other investors observe the upward trend and do not want to lose the opportunity of making profits even if they do not believe that the asset is cheap. However, herding behavior is much more interesting on downward trends. Any time prices follow a downward trend, some analysts will justify it due to certain causes while some other analysts will not be able to justify the movement. If the downward trend strengthens, both those who think that there are information that supports the movement as well as those that think that the movement has no support will tend to adjust their portfolios to avoid any losses as far as this adjustment is still possible.

Fromlet (2001) distinguishes two different types of herding behavior: voluntary and enforced. The voluntary herding corresponds to those agents whose assessments are in line with the herd, and the enforced herding behavior is that of the players on financial markets that might think that is not worth while to fight against the herd, and follow the trend of the market to avoid being trampled on their initial positions. In this sense, countertendency investors might slow down the downward trend, although is very unlikely that they could invert the market trend. Besides, institutional investors would enhance the herding behavior. However, the role of the institutional investors shall be taken carefully given that they accede to a better quality information, and thus, can contribute to the information cascades rather than to the herding behavior. However, the fact that we cannot distinguish between information cascades or herding behavior does not affect to the analysis implemented here. The purpose of the paper is to provide tools to detect episodes of information cascades or herding at the very beginning, but not to determine whether these market movements are due to information cascades or herding, which we think that should be tackled in future research.
Herding behavior is reinforced by two phenomena: the varying availability of information and the preference for certain news. Information is not easily available to all agents in the market. Moreover, it is also possible that some agents do not have the skills or the intuition to apply it in an appropriate way (Fromlet, 2001). In this sense, if only a few investors know about a very negative piece of news (such as a Government inability to pay its external debt) they will trade discreetly in the market selling the Government bonds that they hold in their portfolios. As long as the trading volume increases and/or prices decrease in the process of getting rid of these Government bonds, there will be sharp uninformed agents that will perceive this discreet flight. They will follow the flight, making this movement even more evident to the rest of the market participants until prices finally tumble.

Finally, and especially regarding market stability, the preference for certain news also plays an important role among the factors that boost the herding behavior. This phenomenon reflects the fact that agents are reluctant to change their predictions and recommendations. This attachment to their first assessment might underestimate the importance of new information, particularly in the presence of relatively unimportant news that supports the old forecast (Fromlet, 2001). The formation of speculative bubbles is closely related to the preference for certain news. If neither specialists nor authorities perceive in time the divergence among the real economy indicators and the evolution of market prices, or even if they cannot act effectively to reduce this divergence, then the stability of the financial markets might be jeopardized. On the bubble limit, some agents will revise their positions and expectations and they will start selling at perceptibly lower prices. If the volume of these operations at lower prices increases and a herding behavior shows up, then the probability of the bubble to burst increases.

In sum, the detection of herding behavior in time is of interest to investors to maintain the value of their portfolios. This is also of interest to authorities in order to maintain the stability of the financial system. In the following sections, we will develop a simple model that serves as the basis to construct an indicator that can be of help in detecting herding behavior episodes in advance: the distribution of the market strength across returns.

3 Methodology

This section presents a new model for herding behavior that serves as the basis for the construction of the indicator of the strength of the market movement.
This new indicator detects herd behavior in the very short run; therefore, it can be useful to avoid in extremis the possible extreme outcomes of such behavior.

Herding behavior is highly noticeable during stock market crashes in which information has not been incorporated to prices at the right time or when there is an overreaction of the market. When this herding behavior becomes evident, the asset prices are severely depreciated and the trading volumes are quite high. At this point, one could say that the market movement is very strong since it is not only that some operations support the fall in prices, but also that the vast majority of them sustain such movement. This is due to agents who want to leave the market as soon as possible and offer increasing volumes at lower and lower prices to avoid being trampled. However, there is a time interval in which the herding behavior is non evident and where authorities can intervene to transmit tranquility to the markets.

Below we present a model that considers the individual behavior pattern to assess asset prices and then, we explain the functioning of the market as a result of the individual patterns. Afterwards we describe the indicator of the strength of the market movement.

3.1 Behavior of the individual investor

To explain the asset-pricing model it is necessary to make certain assumptions on the criteria that agents use. We will assume that each investor has her own criteria such that the price of an asset can be decomposed on a reference value plus a second component that considers all the individual factors that correct the reference value. Then, the asset price is given by:

\[ p_i = \nu + \psi_i, \]

where,

- \( p_i \in \mathbb{N} \) is the price assigned by the investor \( i \) to the asset.
- \( \nu \in \mathbb{N} \) denotes the reference value, it constitutes a key element of the model.
- \( i = 1, \ldots, N \), where \( N \in \mathbb{N} \) is the total number of investors that participate in the market.
- \( \psi_i \in \mathbb{R} \) indicates the adjustment to the reference value.

The selection of the reference value, \( \nu \), is a fundamental issue in the model. Among the different possibilities to assess the reference value, \( \nu \), we discuss three of them:
The present value of all future cash flows, which would be the ideal reference if we exactly knew the flows and the discount factors. Unfortunately, it is not possible to know any of these magnitudes accurately and its estimation is subject to significant biases.

The asset value determined by the fundamental analysis, which is also subject to severe estimation biases given that the frequency of the data included in this analysis is much lower than the appropriate in technical analysis.

The last option is to consider a neutral price, for instance, the opening price for the trading day. The main advantage of this option is that it does not incorporate any estimation bias. Also, and comparing to the closing price of the previous day, is that this is consistent with the calculation of the relative volume.

The adjustment that each agent applies to the reference value, $\psi_i$, considers all the subjective components considered by the individual investor in her valuation rule. Among these components, those of special relevance are characterized for being non-rational such as the preference for certain news, overconfidence and control illusion, imitation processes, and herding behavior or information cascades. This adjustment term depends, among other factors, on the following variables:

- The asset price during a given period, which might vary among agents, $\pi_i$
- The evolution of other asset prices used as benchmark for valuation, $\kappa_i$
- The interpretation of news, $\eta_i$
- The fact that the portfolio is running profit or losses at that time, $d_i$
- The individual’s risk preferences, $\lambda_i$.

It should be noted that the importance of each component might vary between agents. Therefore, the importance assigned by each individual to each of the factors can be different. Moreover, the relation between the factors provided by $f(\cdot)$ might be non-linear:

$$\psi_i = f(\pi_i, \kappa_i, \eta_i, d_i, \lambda_i).$$

(2)

As a result, each individual investor expects the market price to rely between an upper and lower bound. Therefore, the agent’s own interval for the prices is given by:

$$p_t \in [p_t^{\text{low}}, p_t^{\text{up}}].$$

(3)
Any time the condition in (3) is not satisfied (so that the price exceeds the upper or lower bound) will make the investor to revise his expectations and justify the change in the thresholds. If she succeeds, she will establish new upper and lower bounds on the threshold. Nonetheless, if she finds no explanation for the price variation, then she will probably follow the market trend.

3.2 Behavior of the market

We assume that each agent follows her own pricing criteria as long as the market price relies between the upper and lower bounds of the agent’s valuation interval. However, according to the literature on herding behavior, as soon as the price falls out of the valuation interval, the agent will follow the market dominant trend to avoid being trapped in her initial position, that is:

\[ p_i = \begin{cases} 
\nu + \psi_i & \text{if } p_t \in [p_{i,\text{low}}, p_{i,\text{up}}] \\
\nu + \psi_{\text{market}} & \text{otherwise}
\end{cases} \]

(4)

where \(\psi_{\text{market}}\) is the adjustment to the reference value observed in the market.

We consider two possibilities in this model:

1. A balanced market behavior in which agents maintain their valuation rules:

\[ \psi_{\text{market}} = \sum_{i=1}^{n} \psi_i \approx \varepsilon, \]

(5)

where \(\varepsilon\) denotes a smooth market movement based on the public and private information available to the agents.

2. However, in some cases when a negative piece of news arrives at the market, the asset prices may go beyond the lower bound, and agents could follow the market trend if the information publicly available is not sufficient to explain such a big change. In this way, the strongest market trend, \(\psi_d\), will dominate the weakest one, \(\psi_{nd}\). Therefore, the adjustment to the reference value will be given by:

\[ \psi_{\text{market}} = \sum_{i=1}^{n} \psi_{d,i} + \sum_{i=1}^{n} \psi_{nd,i} \neq \varepsilon, \]

(6)

The fact that one trend dominates the other depends, among other factors, on the messages that the market receives: those renowned persons or entities
with high credibility have a greater ability to influence investors’ perception about the market circumstances. Besides, there are private and public institutions (such as central banks, institutional investors or private investors with outstanding financial conditions) that are capable to influence the evolution of market prices.

The spillover of the dominant trend among agents follows the next mechanism: each individual has a different interval where the upper and lower bounds are given by \([p_{i}^{low}, p_{i}^{up}]\). Therefore the herding behavior takes place on a sequential basis provided that not all the agents detect at the same time the herding behavior since. Concretely, as long as the market prices go beyond the investors’ thresholds bounds, more and more agents will follow the dominant market trend.

Taking all the above mentioned factors into account, we propose to calculate the strength of the market movement (i.e. the proportion of the market following a certain trend), \(\vartheta_{d,\tau}\), as the ratio of the market correction of the trading operations that follow that given trend (i.e. \(\psi_{d}^{i}\)) relative to the correction of the reference value of the market, \(\psi_{market}\):

\[
\vartheta_{d,\tau} = \frac{\sum_{i=1}^{n} \psi_{d}^{i}}{\psi_{market}}.
\]

But, how to measure \(\psi_{i}\)? Agents’ preferences regarding risk, the period and the prices used as reference, or the benchmark assets are not easy to model and this target would go beyond the scope of this paper. However, if we assume that we have a representative agent, all those aspects may be well reflected (although probably not completely) on the trading prices and volumes. The obvious indicator to assess \(\psi_{i}\) is the price change with respect to the reference value, however, this calculation would omit the information content in the trading volume.

We then calculate \(\psi_{i}\) as the product of the price change with respect to the reference price times the trading volume of the operation. Besides, to avoid that positive and negative price changes compensate each other, we calculate the absolute value of the price changes. Therefore, the correction of the reference value observed on each trading operation is given by:

\[
\psi_{i} = |\ln\left(\frac{price_{i}}{reference\_price_{i}}\right)| \times volume_{i}.
\]

In order to calculate the strength of the market movement for each return interval, \(d\), and time interval, \(\tau\), we use equations (7) and (8) to get the following expression:
\[ \vartheta_{d,\tau} = \frac{\sum_{i=1}^{d} |r_{\text{return},i,\tau}| \times v_{\text{volume},i,\tau}}{\sum_{i=1}^{D} |r_{\text{return},i,\tau}| \times v_{\text{volume},i,\tau}} \times 100, \quad (9) \]

where the sequence \( i = 1, \ldots, d, \ldots, D \), identifies the operations ordered according to their associated return, so that the \( d \) first operations support the analyzed trend and \( D \) represents the total number of operations recorded in the time interval, \( \tau \). The parameter \( \vartheta_{d,\tau} \) measures the strength of the market movement and ranges from 0 (indicating there are no operations supporting that trend) to 100 (where all operations support the trend).

For illustrative purposes, we present a very simplistic example on Table 1, which shows the daily reference value (opening price), quoted price, and trading volume for a given asset between 9.30am and 10.30am. To calculate the strength of the market movement supporting certain trend (for instance, a decrease in prices by more than \( X\% \), then \( r \leq X\% \)), we have to compute the coefficient \( \vartheta_{d,\tau} \) defined above:

[INSERT TABLE 1 AROUND HERE]

- **Example 1**: Decrease higher than 2%. The table above contains seven operations, out of which, four of them indicate a decrease in the market higher or equal to -2%. According to this table, the strength of this movement is computed as follows:
  \[ \vartheta_{r \leq -2\%, 9:30-10:30} = \frac{16+72+6+6}{110} \times 100 = 81.82\% \]

- **Example 2**: Decrease higher than 6%. In this case, just two of the seven quoted operations support this possibility. However, the volume traded in these operations is important and, then, the impact on the movement strength is significant. In fact, the result says that the 70.91% of the volume traded in the market is providing a return smaller than 6%. The computation is as follows:
  \[ \vartheta_{r \leq -6\%, 9:30-10:30} = \frac{16+72}{110} \times 100 = 70.91\% \]

The above examples are exaggerated but they help to understand the empirical exercise developed in the next section.
4 Empirical application

4.1 Data
The empirical analysis is performed over the Spanish futures on IBEX-35, for which data were obtained from the official market for these futures, Mercado Español de Futuros Financieros de Renta Variable. A stock index future reflects the market evolution and, in contrast to the index, the future is traded. Then, there is a trading volume available. The database includes all trading operations between January 2nd, 2004 and September 29th, 2004. In more detail, we consider the price and trading volume for the nearest maturity, as they provide the highest liquidity.

4.2 Empirical results
This section shows the usefulness of the new indicator of strength of the market movement to identify the distribution of strength across returns and to calculate a representative return that improves the robustness of the indicators employed up to now. The results indicate that in days of relative calmness the closing price seems to be a good indicator of what has happened during the day. However, when there is an important discount of relevant information and herding behavior appears on the market, the return based on closing prices may not be representative of what has happened during the day due to odd operations with low trading volume and big changes in prices that frequently take place at the market closing times. Therefore, we propose to use the market strength weighted return as representative return as it is a more robust estimate of the market evolution during the day. This way of computing the market return can improve the information used in the financial analysis and can help to mitigate the jumps in the series originated by punctual trading operations with small volume and big changes in prices at market closing times.

4.2.1 Strength of the Market Movement
By computing the strength of the market movement, we obtain an indicator that mixes the price and volume evolution, which incorporates further information to the classical methods used in technical analysis. For illustrative purposes we present a candlestick chart on Figure 1, which includes some representative prices (open, high, low and last price), as well as the total trading volume for each time period within the trading date. As Table 2 illustrates, using this instrument we can not distinguish the proportion of the market that supports each potential market trend. As for example, on March 15th 2004, in the time period
between 9:00am and 9.30am, more than 4,524 contracts with prices between 7,778 and 7,914 were traded. However, this graph does not help to identify the trading volume related to each price movement. As shown later, the analysis of the strength of the market movement can provide this information.

[INSERT FIGURE 1 AROUND HERE]

[INSERT TABLE 2 AROUND HERE]

Using equation (9) we proceed to calculate the strength of the market movement per each return interval on March 15th 2004, for each 30 minutes interval, which is reported on Table 3. Note that trading started in a large interval for returns because of the substantial information published that morning related to a) the unforeseen result of the Spanish general elections and b) the confusion created by the terrorist attack that happened in Madrid 4 days before.

Between 9:00am and 9.30am, most of the trading operations imply positive returns. However, one can see a small proportion of trading operations with associated negative returns. Some herding behavior arose as the market was assimilating the news. In a way, on that date the market was continuously correcting the initial positions, closing the trading day with a decrease close to -2%.

[INSERT TABLE 3 AROUND HERE]

4.2.2 Distribution of the Strength across Returns

The distribution of the strength across returns provides a general overview of what the market considers in each time period. In this way, one can see the price interval in which the market is moving and obtain a relevant measure of the volume related to each price. Figure 2 shows this distribution of the market strength across returns for some time intervals on March 15th 2004. It provides significant information on the market activity. For instance, the curve observed between 9:00am and 9.30am is especially interesting as one can identify a number of trading operations whose prices are much smaller than the average price of this time period.

[INSERT FIGURE 2 AROUND HERE]

As described in the model, in presence of a herding behavior episode, we expect a different shape for the distribution of the strength across returns given the evolution of the market. Taking into account that on March 15th 2004,
the market was discounting a large set of information after the terrorist attacks in Madrid and the unexpected result in the general elections in Spain, one observes what can be described as herding behavior or information cascade. Between 9:00am and 9.30am, the distribution of the strength across returns seems to reflect that a certain group of investors was closing positions or arriving at a new equilibrium price. In fact, these operations pointed to a significant decrease in prices (see Figure 2).

A quiet behavior in the market is related to a smooth movement of the prices, it is also associated with an homogeneous distribution of the strength across returns. As Figure 3 illustrates, this is the case of September 21st 2004, when all the contracts were traded in a rather narrow interval of returns (i.e. between -0.2% and 0.3%).

[INSERT FIGURE 3 AROUND HERE]

In contrast to a quiet day, Figure 4 shows a day (March 11th, 2004) characterized by high uncertainty and a significant discount of information. On this date, the city of Madrid suffered a dramatic terrorist attack, three days before the Spanish general elections on March 14th. Although the day started with very different opinions and with returns between -0.8% and +0.3%, the Distribution of the Strength of Market Movement between 12.00 and 12.30 is very significant. The motivation may be related to the first official release of the number of victims, which caused the returns to move to the interval \([-2.0, -0.6]\).

[INSERT FIGURE 4 AROUND HERE]

In summary, there is relevant information embedded in the trading volume that is underused by the traditional methods of financial analysis. This information helps to obtain a clearer view of the potential trends that the investors are considering. Using the new methodology introduced in this paper, an investor could assess whether her strategy equates that of the market and then, take later decisions.

4.2.3 Representative Market Return: the Market Strength Weighted Return

Figures 2 to 4 question the validity of summarizing the daily facts in a single price (opening, maximum, minimum or closing). In short, we propose as a representative market return, the sum of intraday returns weighted by the
movement strength, which is computed as follows:

\[ msw_{r_{t,t+1}} = \sum_{return=-\infty}^{+\infty} return_{(t,t+1)} \times \theta_{r_{t,t+1}} \]  \hspace{1cm} (10)

Compared to the return based on closing prices, the market strength weighted return shows a very similar evolution in calm trading days while, at the same time, this new calculation for the representative return mitigates the impact of trading operations with extreme prices and small trading volumes. This type of operations could occur in days with high degree of uncertainty and correspond to potentially non-representative data. As shown on Figure 5, one could test that the return based on closing prices is more extreme than the market strength weighted return.\(^1\)

[INSERT FIGURE 5 AROUND HERE]

Finally, Figure 6 reports the accumulated probability distributions for the market strength weighted return and for the return based on closing prices. It should be clear the presence of more extreme values when considering the return computed using the closing price, while the market strength weighted return decreases the impact of the extreme quotes if their volume is relatively small with respect to the total daily trading volume.

[INSERT FIGURE 6 AROUND HERE]

Considering the importance that must be given to trading operations with small volume, it seems reasonable to use the market strength weighted return as a daily representative return provided that this indicator takes into account not just the impact of the price change but also, the relative size of the operation. In this way, an extreme closing price with a small volume traded would have little impact on the representative return. Then, the representative price of the day is closer to that of the trading operations with a significant trading volume in relation to the total daily trading volume.

5 Conclusions

Investors’ opinion on the market evolution is reflected not just in prices but also in trading volumes. However, the information embedded in those trading

\(^1\)This is an important note as we are interested in obtaining an objective measure of the behavior of the market on a given date
volumes is frequently underused by the traditional methods of financial analysis. This paper proposes an indicator that combines the information content in prices and trading volumes, labeled strength of the market movement, which constitutes a helpful instrument to identify the degree of support in the market for a certain trend. Then, we propose the distribution of the strength across returns, which is a useful tool to quickly identify the opinion of investors about the asset price per time interval. Finally, we propose the market strength weighted return as a more robust measure of the evolution of the market. The empirical analysis is performed on the futures on IBEX-35 over the period between January and September 2004.

The results support the fact that there is relevant information embedded in the trading volume, and that this information may be relevant to assess the evolution of the market. The distribution of the strength across returns behaves differently on calm and nervous trading dates, and helps to detect the market opinion about the evolution of prices in the very short term. Besides, the market strength weighted return seems to be more robust than the return based on closing prices on the estimation of the evolution of the market. Nevertheless, further research on this last issue should be implemented to analyze the behavior of the market strength weighted return.

All in all, the tools presented in this paper could be of help for investors in order to obtain information on the aggregate opinion in the market, and they could be also useful for the monetary authorities in sustaining market stability. Last, but not least, the market strength weighted return could improve the analysis of time series using a more complete and representative measure of the market evolution.
References


Tables and Figures

Table 1
Calculation of the support for a market trend

This table illustrates the calculation of the market strength indicator for a given date and time interval. The first columns contains the time, the second contains the reference value for the day, \( \nu \), which in this case is the daily opening price. The third column shows the quoted price, \( p_t \), and the fourth presents the trading volume, \( V \). The last two columns contain the correction for the reference value, \( \psi_i \), calculated as the percentage deviation of the quoted prices from the reference value, the final column presents the product of the price correction times the trading volume for each operation.

| Time | Ref. value | Price | Volume | \( \psi_m \) | \( |\psi_m \times V| \) | \textit{return} \leq -2\% | \textit{return} \leq -6\% |
|------|------------|-------|--------|-------------|-----------------|-----------------|-----------------|
| 9:30 | 5,000      | 4,950 | 3      | -1.0        | 3               |                 |                 |
| 9:40 | 5,000      | 4,900 | 2      | -2.0        | 6               | 6               | 6               |
| 9:50 | 5,000      | 5,075 | 10     | 1.5         | 15              |                 |                 |
| 10:00| 5,000      | 4,700 | 12     | -6.0        | 72              | 72              | 72              |
| 10:10| 5,000      | 5,100 | 1      | 2.0         | 2               |                 |                 |
| 10:20| 5,000      | 4,850 | 2      | -3.0        | 6               | 6               | 6               |
| 10:30| 5,000      | 4,700 | 1      | -6.0        | 6               | 6               | 6               |
| TOTAL|            |       | 110    | 90          | 78              |                 |                 |

\( \theta_{r \leq X\%:9:30-10:30} \) = 81.82\% 70.91\%
Table 2
Market Evolution on March 15th 2004

This table shows the market evolution in terms of trading volume, opening price, maximum and minimum prices, and closing price for each 30 minutes time interval on March 15th.

<table>
<thead>
<tr>
<th>Time interval</th>
<th>Trading Volume</th>
<th>Opening price</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Closing price</th>
</tr>
</thead>
<tbody>
<tr>
<td>09.00-09.30</td>
<td>4,524</td>
<td>7,830</td>
<td>7,914</td>
<td>7,778</td>
<td>7,871</td>
</tr>
<tr>
<td>09.30-10.00</td>
<td>2,757</td>
<td>7,870</td>
<td>7,872</td>
<td>7,845</td>
<td>7,852</td>
</tr>
<tr>
<td>10.00-10.30</td>
<td>1,741</td>
<td>7,853</td>
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Table 3  
Distribution of the Strength across Returns, March 15th 2004

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This figure shows the usual candlestick chart from technical analysis where trading volume is in bars (left axis) and the open, high, low and last prices (right axis) per 30 minutes time interval on March 15th, 2004.
Figure 2
Distributions of Strength across Returns as of March 15th, 2004

This figure presents various Distributions of the Strength across Returns for several time intervals on March 15th, 2004.
Figure 3
Distributions of Strength across Returns as of September 21st 2004

The figure shows a tranquil day with similar Distributions of the Strength across Returns during the day.
Figure 4
Distributions of Strength across Returns as of March 11th 2004

The figure shows a high uncertainty trading date in which relevant news was released to the market.
The figure shows the relationship between the Movement Strength Weighted Return and the return based on closing prices over the period from January to September 2004.
This figure displays the accumulated probability distributions for the Movement Strength Weighted Return and the return based on the closing price over the period from January to September 2004.